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The Effect of a Selected Progressive Resistance Running Program on Circulorespiratory Efficiency, Power and Free Running Speed

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THE EFFECT OF A SELECTED PROGRESSIVE RESISTANCE RUNNING PROGRAM ON CIRCULORESPIRATORY EFFICIENCY, POWER AND FREE RUNNING SPEED

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser — Date

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THE EFFECT OF A SELECTED PROGRESSIVE RESISTANCE RUNNING PROGRAM ON CIRCULORESPIRATORY EFFICIENCY, POWER, AND FREE RUNNING SPEED

Abstract

MERL A. HAMAK

Under the supervision of Associate Professor Glenn E. Robinson

The purpose of this investigation was to determine the effects of a selected progressive resistance running program on circulorespiratory efficiency, power, and free running speed of runners. A selected interval training program was employed in order to compare the progressive resistance training program to an accepted method of training.

Forty-five male, freshman students at South Dakota State University were divided into two experimental groups and a control group. The subjects in the experimental groups participated in a six-week training program of either resistance running or interval training.

All subjects were tested at the beginning of the investigation, immediately following completion of the training program, and again 10 days later. Oxygen debt repaid from a standardized treadmill run, power developed by the legs, free running speed, and the time for a 600-yard run were investigated.

The data collected during the testing were recorded and analyzed statistically to determine what effect the resistance running program had on circulorespiratory efficiency, power, and free running speed.

The results of the findings indicated that the resistance running program had no significant effect on oxygen debt repaid, power, free running speed, and the elapsed time for the 600-yard run. This was indicated between the groups and within the group. The interval running group made statistically significant improvements when compared to the control group, from pre-test to initial post-test, for oxygen debt repaid, which indicated improvement in circulo-respiratory efficiency. The interval running group also made a significant improvement when compared to the control group, from pre-test to initial post-test and from pre-test to final post-test for the 600-yard run. Within the interval running group statistically significant improvement was noted from pre-test to initial post-test for the 600-yard run.

ACKNOWLEDGEMENTS

The writer wishes to express his sincere appreciation to Professor Glenn E. Robinson and Mr. William E. Fritz for their assistance throughout the course of the work reported here and the preparation of this thesis.

The interest, desire, and work of the 45 freshmen volunteers is gratefully appreciated.

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Chapter I

INTRODUCTION

Reasons for Study

The modern-day athletic coach constantly searches the literature for coaching technique articles written with particular emphasis on training methods of athletes that develop three fundamentally important components relative to improving athletic performances. The components are circulorespiratory efficiency, power, and free running speed. Many coaches are limited in the practice time and space that they have at their disposal; therefore, any training program that saves time and can be conducted in a limited area would considerably lessen coaching problems. One such training method which has been receiving attention of the athletic coach is resistance running using a commercial device, the Exer-Genie.

While resistance exercise programs have been employed to improve athletic performances, coaches in the running sports either have used resistance running very little, or have not reported their training routines. In the writer's opinion, this lack of reported routines may be the result of the difficulty of placing athletes in resistance running training situations that exercise the primary muscles of propulsion.

Proponents of the Exer-Genie, a commercial resistance device, have claimed that endurance and strength can be developed

while saving time and space. The pamphlet Exer-Genie Exerciser[1]

[1] Exer-Genie Exerciser, pamphlet, "It's Fun to Get Fit With Exer-Genie Exerciser," Advertisement by Exer-Genie, Inc., Fullerton, California, 1966.

states the following:

> By working against resistance the athlete is actually working in slow motion which allows the coach to study his form in detail. At the same time the athlete is building muscles used in his particular sport or event as well as increasing stamina, endurance, flexibility and technique.

The scientific principle of increasing the work load or resistance, against which the muscles being exercised work, as strength increases, has been employed extensively in modern times by individuals interested in improving athletic strength and endurance. The method of training which employs this principle is called progressive resistance exercise. Coaches have become most interested in resistance running as an important phase of resistance exercise.

Statement of Problem

The purpose of this investigation was to determine the effects of a selected progressive resistance running program on circulorespiratory efficiency, power, and free running speed of runners.

As a subproblem, a selected interval running program was employed in order to compare statistically the results of the progressive resistance training program to an accepted method of training.

Limitations of Study

1. This study was limited to volunteers from the basic instruction program in physical education at South Dakota State University during the spring semester 1967.

2. The length of the training program was 28 work periods.

3. No attempt was made to control the outside activities of the subjects, except that they could not be a member of a University sponsored athletic team during the time that they were involved in the investigation.

4. No subject received instruction concerning correct mechanical running form.

Definition of Terms

1. Resistance running was defined as running against an external force that could be regulated as desired.

2. Interval running was defined as a form of training. In this study it involved five factors: (1) the distance of the training runs, (2) the number of repetitions of the training distance, (3) the speed of the training runs, (4) the duration of recovery period after each training run and (5) the type of activity, walking, during the recovery period after each training run.

3. Exer-Genie was the commercial resistance device used to create the force for the resistance running group to work against.

4. Power was the time rate of doing work, or force times velocity. Its development demanded fast, explosive movements against the resistance of gravity.

5. Free running speed was defined as speed of running without the factor of starting blocks and without instructions concerning correct mechanical form.

6. Warm-up, as accepted for this study, was exercise as physical and mental preparation for strenuous exertion. The purpose for warm-up was the physiological and psychological preparation for exertion.

7. Warm-down, as accepted for this study, was the physiological process of allowing the body functions to return to a near normal state after strenuous exercise. The warm-down was accomplished through the use of "jogging" and "walking" after each day's training period was completed.

8. The basic instruction program of physical education is a one-year physical activity program required of all freshmen at South Dakota State University in order to fulfill graduation requirements.

9. Non-athletes in this investigation were defined as those male freshman students not participating in the intercollegiate athletic program at South Dakota State University.

Chapter II

REVIEW OF RELATED STUDIES

Introduction

The review of literature was confined to research concerning the development of circulorespiratory efficiency, power and the use of resistance exercises.

Report of Pertinent Findings

Schneider et al.[2] writes that there can be little doubt that a regular course of physical training promotes greater strength and efficiency to the body. Furthermore, it is generally accepted that the trained man can perform a given amount of work with a smaller consumption of oxygen than the untrained man, thus making a smaller demand on his heart, with the result that it beats less frequently. Even during rest, the heart beats less frequently in the trained than untrained man.

In Werner's[3] opinion, running will make a healthy heart

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[2] Edward C. Schneider, Robert W. Clarke and Gordon C. Ring, "The Influence of Physical Training of the Basal Respiratory Exchanges, Pulse Rate, and Arterial Blood Pressure," The American Journal of Physiology, July, 1927, p. 255.

[3] J. Werner, "Cross Country Training Techniques," Scholastic Coach, September, 1953, p. 14.

stronger and more efficient, that the lungs will function more completely and efficiently, and, in fact, that all of the body's organs and systems will benefit by systematic training exercises.

McCloy and Young[4] outlined the following factors as those

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[4] Charles H. McCloy and Norma D. Young, Tests and Measurements in Health and Physical Education, p. 290.

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which accompany "good condition": slow pulse, small rise in pulse rate upon arising from a reclining position, normal systolic pressure, rise of systolic pressure upon arising from a reclining position, fairly high diastolic pressure, relatively high venous pressure, relatively small increase in pulse rate after exercise, and a rapid pulse rate recovery after the cessation of exercise.

Doherty[5] states the following concerning the efficiency and

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[5] Ken Doherty, "Interval Training," Scholastic Coach, March, 1956, p. 20.

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fatigue of runners:

> The efficiency of runners in terms of fatigue decreases to the fourth power as pace increases. That is, if we double the speed of running, the oxygen requirements of muscles increase eight times. It is easily understood then that, when practice time is limited doing speed work in practice produces fatigue and constantly increases resistance to fatigue much more quickly than slower pace running. Further, it has been observed that in slower pace running, men are more conscious of the feeling of fatigue and tend to slow their pace before becoming really tired physically.

In discussing training, Willgoose[6] states that with training

[6] C. E. Willgoose, Evaluation in Health, Education and Physical Education, p. 478.

there is an increase in the total cardiac output, a slower rate of breathing is assumed, and there is a corresponding economy of respiration. When both fit and unfit performers execute the same exhausting amount of work, which neither can sustain in a steady state, the fit man shows a slower maximal heart rate, a larger stroke volume, and a faster return to normal of blood pressure and heart rate.

King[7] referred to cardio-respiratory endurance in the

[7] Louis Chole King, "An Investigation of the Effect of Two Training Programs on Selected Cardio-respiratory Variables of College Women," (M.S. Thesis, University of North Carolina, 1962), p. 2.

following manner:

> The fit individual possesses these components of cardio-respiratory endurance: a) a larger minute volume; b) a slower pulse rate; c) a lower blood pressure; d) a large surface area in the lungs; and e) a larger supply of red blood corpuscles and hemoglobin.

In discussing athletic power, Chui[8] makes this statement:

[8] Edward F. Chui, "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, October, 1950, p. 188.

> The inclusion of these four performance tests in testing criterion was based on the thesis that power (the time rate of doing work, or, force times velocity), when applied by the human body, is the

> essential mechanical factor in the projection of the individual's own body rapidly through space. All these events---sprinting, jumping, and throwing---require maximum, or nearly maximum muscle contractions in a minimum of time and have been well substantiated as valid test items for measuring power. 1) Sargent jump-standing, 2) Sargent jump-running, 3) Standing broad jump, and 4) Sixty-yard sprint.

The opinion of Barba[9] is that a strong body will not give

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[9] Joe Barba, "Questions and Answers for the Distance Runner," The Athletic Journal, September, 1966, p. 68.

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in to fatigue as easily as one which is not uniformly conditioned and, also, that there is a definite relationship between power and speed.

Homola,[10] in his opinion concerning strength and speed,

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[10] Samuel Homola, "Specificity in Muscle Building, Part I," Scholastic Coach, November, 1965, p. 28.

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states the following:

> It has been established that an increase in strength produces an increase in speed. But I doubt that the full value of the strength increase can be utilized if it isn't developed in conjunction with the skill it's to support.

Barba,[11] in his opinion, feels that power is as vital as

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[11] Joe Barba, "Questions and Answers for the Distance Runner," The Athletic Journal, September, 1966, p. 68.

---

endurance when running the last lap of a fast race.

Soule,[12] after careful observation, states that the power

[12] Roger G. Soule, "Mechanics of the Distance Stride," Scholastic Coach, February, 1966, p. 44.

for the forward motion is supplied by the extensors of the driving, or extending, rear leg.

Morehouse and Rasch[13] state the following concerning the

[13] Laurence E. Morehouse and Philip J. Rasch, Scientific Basis of Athletic Training, 1st edition, p. 120.

strength development of muscles:

> Muscles grow larger and stronger only when required to perform tasks that place loads on them which are over and above previous requirements. This is the "overload principle," which is the rationale for all progressive resistance exercise systems. Exercise in which muscles are made to contract slowly with maximal intensity, and in which the contraction is held for a few seconds yields the greatest results.

Karpovich[14] stated that the only way to develop strength was

[14] Peter V. Karpovich, Physiology of Muscular Activity, p. 33.

to exercise the muscles against gradually increasing resistance. For this purpose one may use springs, weights or the weight of the body itself.

Chui[15] stated that strength gains acquired by similar

[15] Edward F. Chui, "The Effect of Systematic Weight Training on Athletic Power," Research Quarterly, October, 1950, p. 190.

programs of isotonic weight training and isometric weight training resulted in an increase in speed when the training movements were repeated with or without resistance.

Athletes who tax their muscles by overloading them with additional resistance, according to Homola,[16] in the actual

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16 Samuel Homola, "Specificity in Muscle Building, Part I," Scholastic Coach, November, 1965, p. 29.

---

performance of their speciality or in weight training exercises simulating the movements made in their speciality, probably acquire a form of strength that would be more useful for specialized skills.

Homola's[17] opinion was that exercise against resistance,

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17 Samuel Homola, "Specificity in Muscle Building, Part I," Scholastic Coach, November, 1965, p. 29.

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whether isometric or isotonic, can activate more muscle fibers than can simple gravity-resistance isotonics done in high repetitions, thus increasing muscle size and building more strength.

Herschberger[18] stated that by working his swimmers against

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18 Richard L. Herschberger, "Give Your Swimmers Enough Rope," Scholastic Coach, January, 1966, p. 22.

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resistance, a long rubber band made from strips of inner tubes, saved time and space and at the same time built strength and endurance.

Gentile,[19] about the Exer-Genie, quotes the track coach at

[19] Don Gentile, A New All-Around Exerciser," Scholastic Coach, January, 1966, p. 28.

Whitefish Bay High School, Milwaukee, Wisconsin, as saying, "By using the long running rope, we could conduct adequate practice sessions by working just five minutes with each runner."

In an advertisement, Exer-Genie Incorporated[20] states that

[20] Exer-Genie Incorporated, Advertisement, Scholastic Coach, October, 1966, p. 73.

an individual using their resistance device can develop techniques at the same time that he builds strength, improve endurance, and increase flexibility by duplicating the exact motion of the sport.

Summary

The related literature seems to be in agreement that circulorespiratory efficiency is an important factor in how long and how hard an individual can perform without fatigue becoming a factor. The literature also appears to be in agreement that the most efficient method for the body to develop increased circulorespiratory efficiency is to work against resistance greater than what the body is accustomed and to duplicate the exact motion of the skill that the individual is working to develop.

In the writer's opinion there appears to be conflicting evidence concerning the exact role of power in athletic performances

at the present time, but the literature tends to indicate a direct relationship between the individual's power and his strength and speed. Also the literature seems to agree that power can best be developed by duplicating, against resistance, the exact movements that the individual needs to make in competition.

Chapter III

PROCEDURE FOR OBTAINING DATA

Introduction

The subjects, the instruments used for obtaining data, and the training programs are described in this chapter.

Subjects

Subjects selected for this study were 18- and 19-year-old male freshmen volunteer non-athletes at South Dakota State University. The subjects were enrolled in the basic instruction program of physical education during the spring semester of 1967.

The 45 subjects for the study were selected randomly from 151 volunteers. These subjects were then divided into three equated groups, the results of a circulorespiratory efficiency test being used as the equating factor. By employing the track pillbox method, the three equated groups were designated as the resistance running group, interval running group, or the control group.

The subjects were asked not to engage in any other form of running program or a strength development program for the duration of the investigation. No restrictions were placed on intramural athletic activities, and the subjects were asked not to change their eating, sleeping, smoking, or drinking habits.

For all tests the subjects were required to wear the basic instruction program uniform to insure freedom of movement. The

subjects wore rubber-soled gym shoes to provide better traction over the gymnasium floor and the dirt track. An informal warm-up was employed prior to the pre-test, initial post-test and final post-test for physiological and psychological purposes.

Instruments for Obtaining Information

Circulorespiratory efficiency, power, free running speed, and the 600-yard run were measured with a pre-test, initial post-test and final post-test to determine the effect of the selected resistance running program and the interval running program.

Circulorespiratory Efficiency

A standard treadmill run[21] was employed to determine the circulorespiratory efficiency of each subject.

[21] Thomas Kirk Cureton, Jr., Physical Fitness of Champion Athletes, p. 314.

The subject stood on the Collins treadmill for 5 minutes breathing oxygen from a closed circuit Collins respirometer and graphically established a normal breathing pattern on the kymograph (Figure 1).

After graphically establishing a normal breathing pattern, the subject ran at 7 miles per hour up a 8.6 percent grade for 1.5 minutes. Upon completion of the treadmill run the subject stood on the treadmill for 5 minutes, continuing to breath oxygen from the closed circuit respirometer, and the oxygen consumed in recovery from the standard treadmill run was graphically recorded by the kymograph.

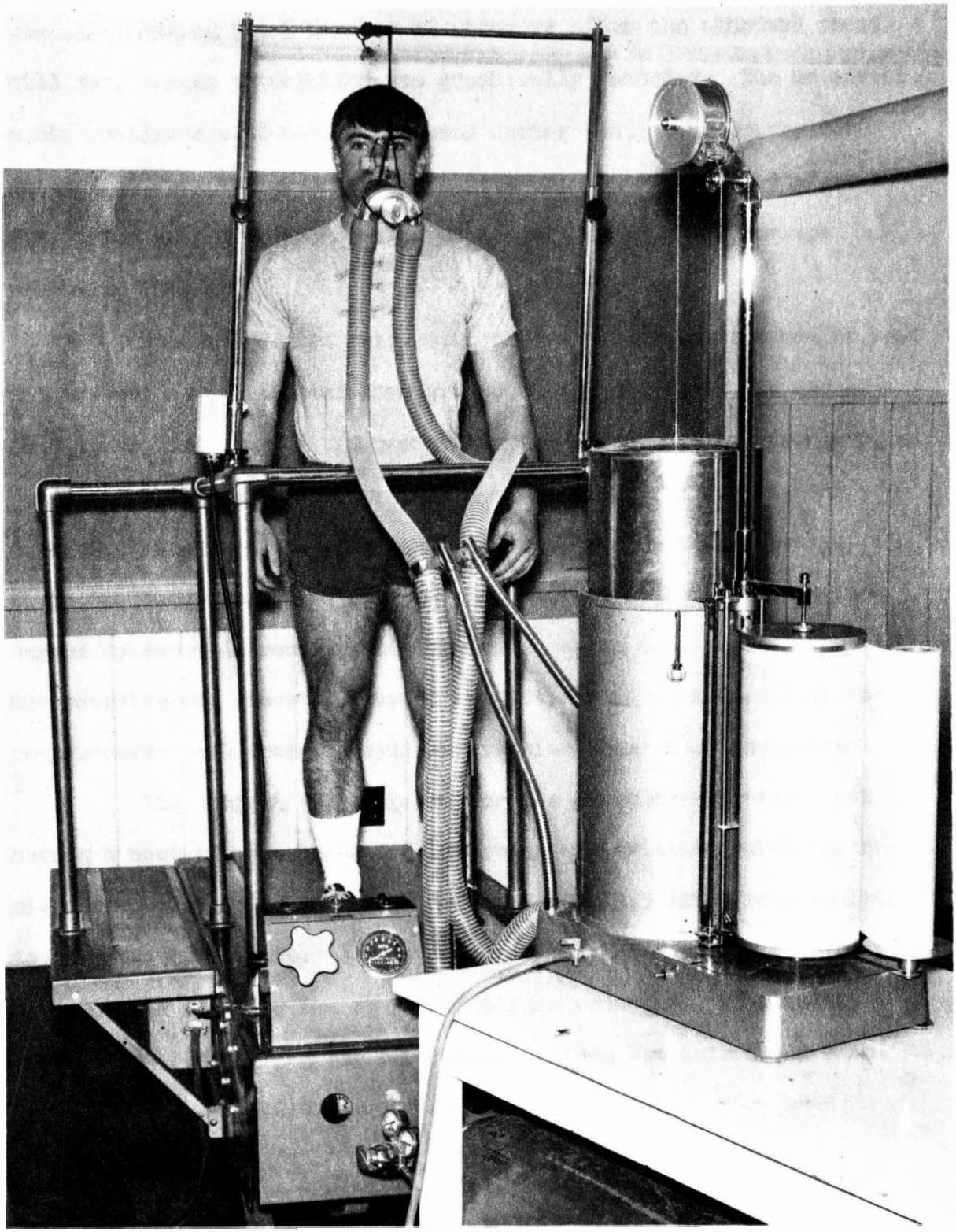

Figure 1. Treadmill and Closed Circuit Respirometer

During the 5 minutes of recovery after the standard treadmill run, oxygen consumption was graphically recorded. The uncorrected cubic centimeters of oxygen consumed during rest and recovery were determined from the graphic record with the aid of the line of best fit, drawn along the bottom tips of the spikes of the kymograph recording (Figure 2).

The uncorrected cubic centimeters of oxygen consumed at rest and in recovery were determined and doubled, because of the use of a 13.5 liter respirometer. A correction factor, determined from oxygen temperature and barometric pressure, was employed to compute the corrected amount of oxygen consumed at rest and during recovery. The corrected oxygen consumed at rest was subtracted from the corrected oxygen consumed in recovery to determine oxygen debt repaid. During the exercise and recovery, oxygen was introduced as needed into the respirometer bell from the cylinder resting under the respirometer.

The subject was prepared for the circulorespiratory test by having a nose clamp secured and inserting a sterilized rubber mouthpiece connected to a hose which led from the 13.5 liter respirometer to the subject's mouth. A kymograph was connected to the respirometer to record graphically the amount of oxygen consumed. To maintain normal breathing during the experiment, oxygen was introduced when needed into the respirometer bell.

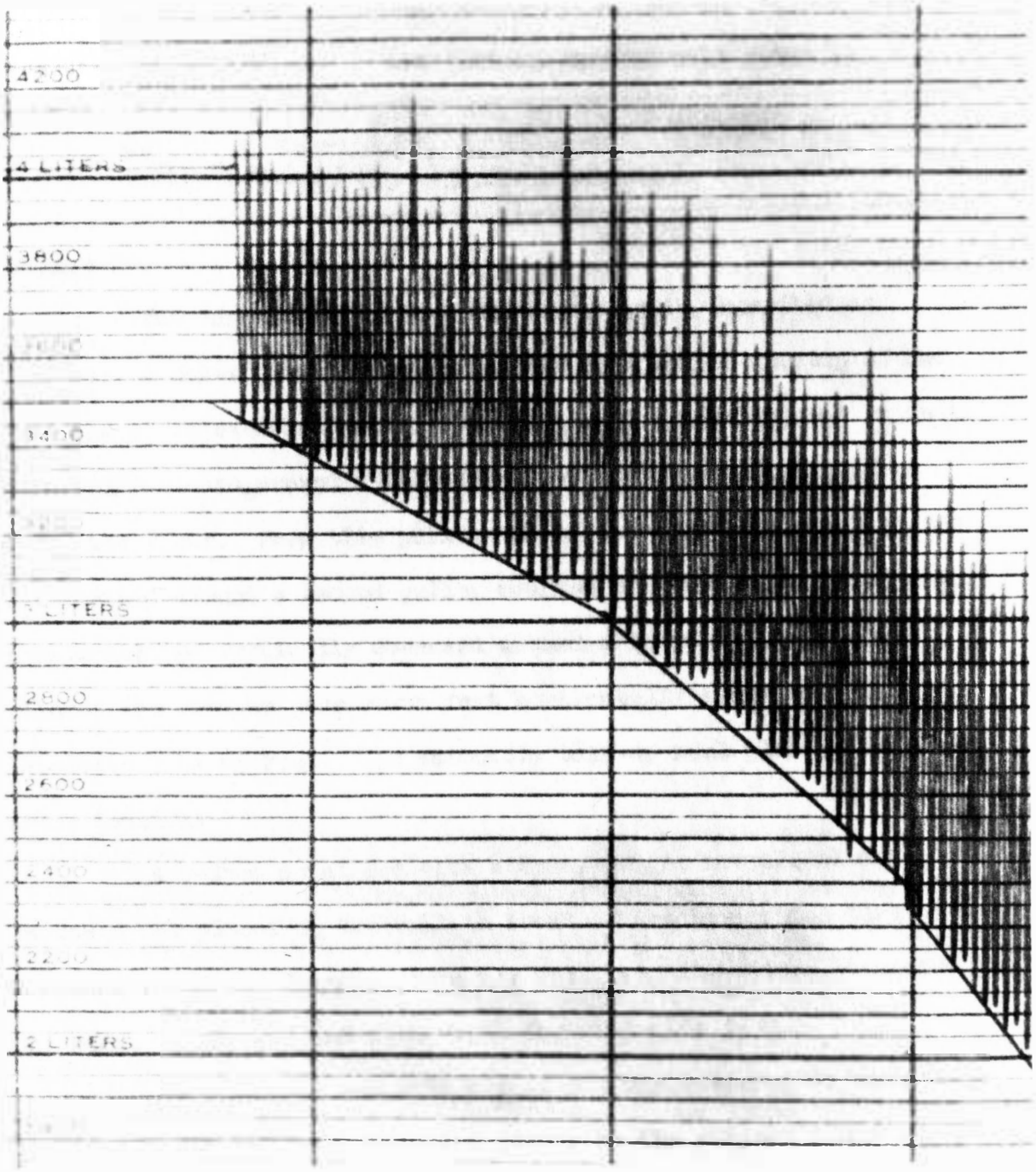

Figure 2. Graphic Record of Oxygen Consumption

Power

The subject was tested for power by the use of the apparatus described by Gray et al.[22] The testing apparatus is shown in (Figure 3).

[22] R. K. Gray, K. B. Start and D. J. Glencross, "A Useful Modification of the Vertical Power Jump," Research Quarterly, May, 1962, p. 230.

The instrument used to measure power is described as follows: a non-stretch braided cord was attached to the top of the head piece, adjustable both horizontally and vertically, and extended vertically upward around a pulley mounted approximately nine feet above the floor. From this pulley the cord passed horizontal to the ceiling and around a second pulley mounted next to the wall. The cord then continued vertically downward around a third pulley, which allowed the cord to pass seven feet horizontally along the wall to an automatic take-up reel. The automatic take-up reel placed the cord under tension.

A 7-foot metal rod with a heavy-weight movable slider attached was placed on the wall in front of the horizontal part of the cord. The rod was 2 inches from the wall, and the slider, attached to the cord, moved back and forth with the subject's jump.

A watercolor pen with a felt tip was fastened to the metal slider and the pen moved with the slider as the subject jumped, making a graphic representation of the jump. Attached to two rollers on the wall was a scroll of paper 62 inches wide on which the watercolor pen

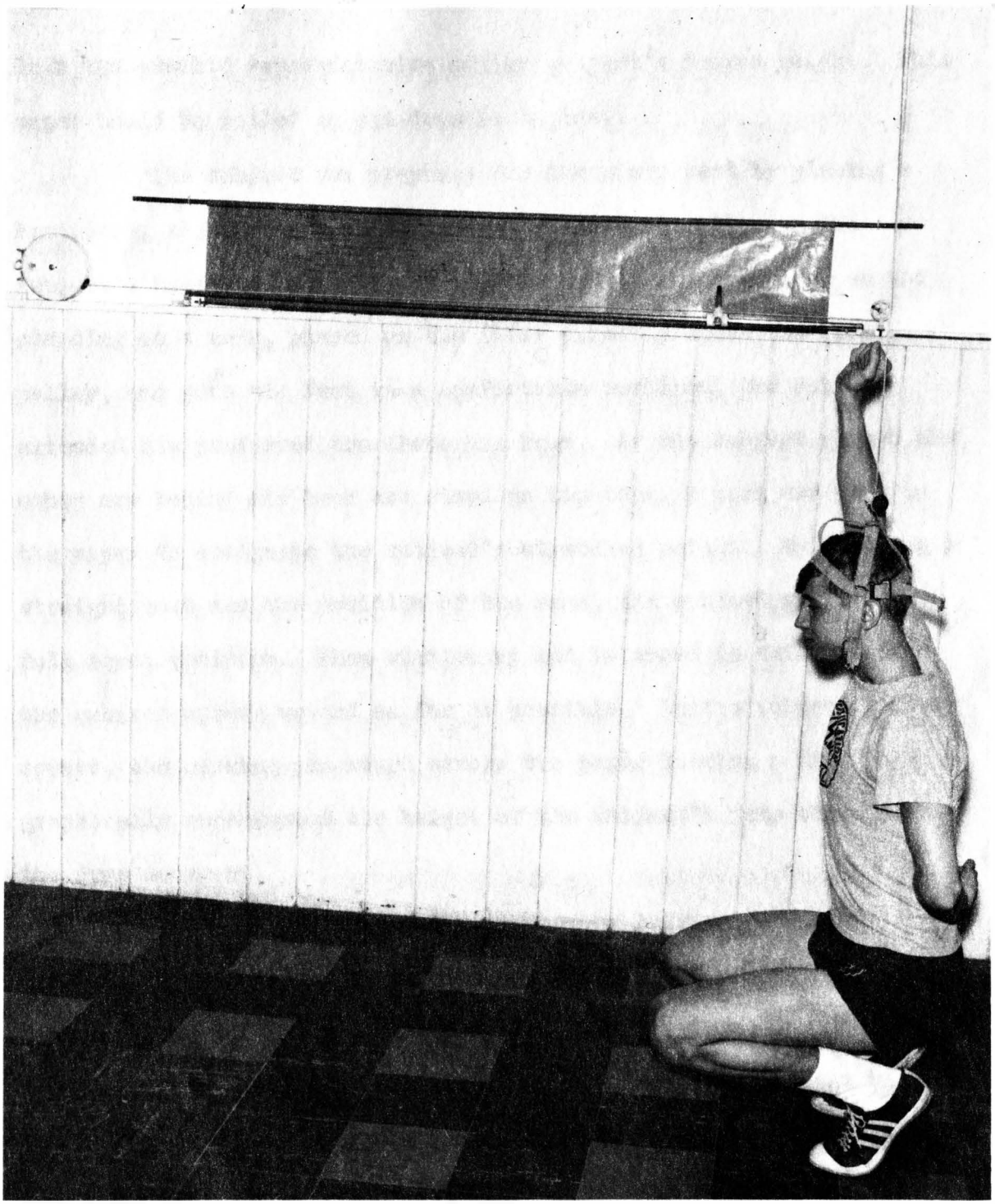

Figure 3. Power Jump Apparatus

left the graphic representation of the subject's jumped height. This paper could be rolled up and down as desired.

The subject was prepared for the power test by placing a headpiece, adjustable both horizontally and vertically, on the subject's head and fastening it tightly. With the headpiece on and standing on a mark, placed on the floor directly under the first pulley, and with his feet in a comfortable position, the subject extended his preferred arm above his head. As the subject placed the other arm behind his back and stood on tip-toes, a mark was made on the paper to designate the subject's stretched height. Maintaining a straight back and the position of the arms, the subject assumed the full squat position. When stationary and balanced in this position, the subject sprang upward as far as possible. As the subject jumped upward, the marking-pen moved across the paper leaving a line that graphically represented the height of the subject's jump throughout the jump movement.

After a jump upward the difference between the point established while standing on tip-toes and the end of the recorded graphic line, made at the height of the jump movement, was measured to the nearest 1/4 inch. Each subject was given three trials in the pre-test, three trials in the initial post-test and three trials in the final post-test. For test purposes the best jump made by the subject at each of the three testing sessions was recorded.

The number of inches jumped was converted to feet by dividing the number of inches by twelve, and this quotient was then

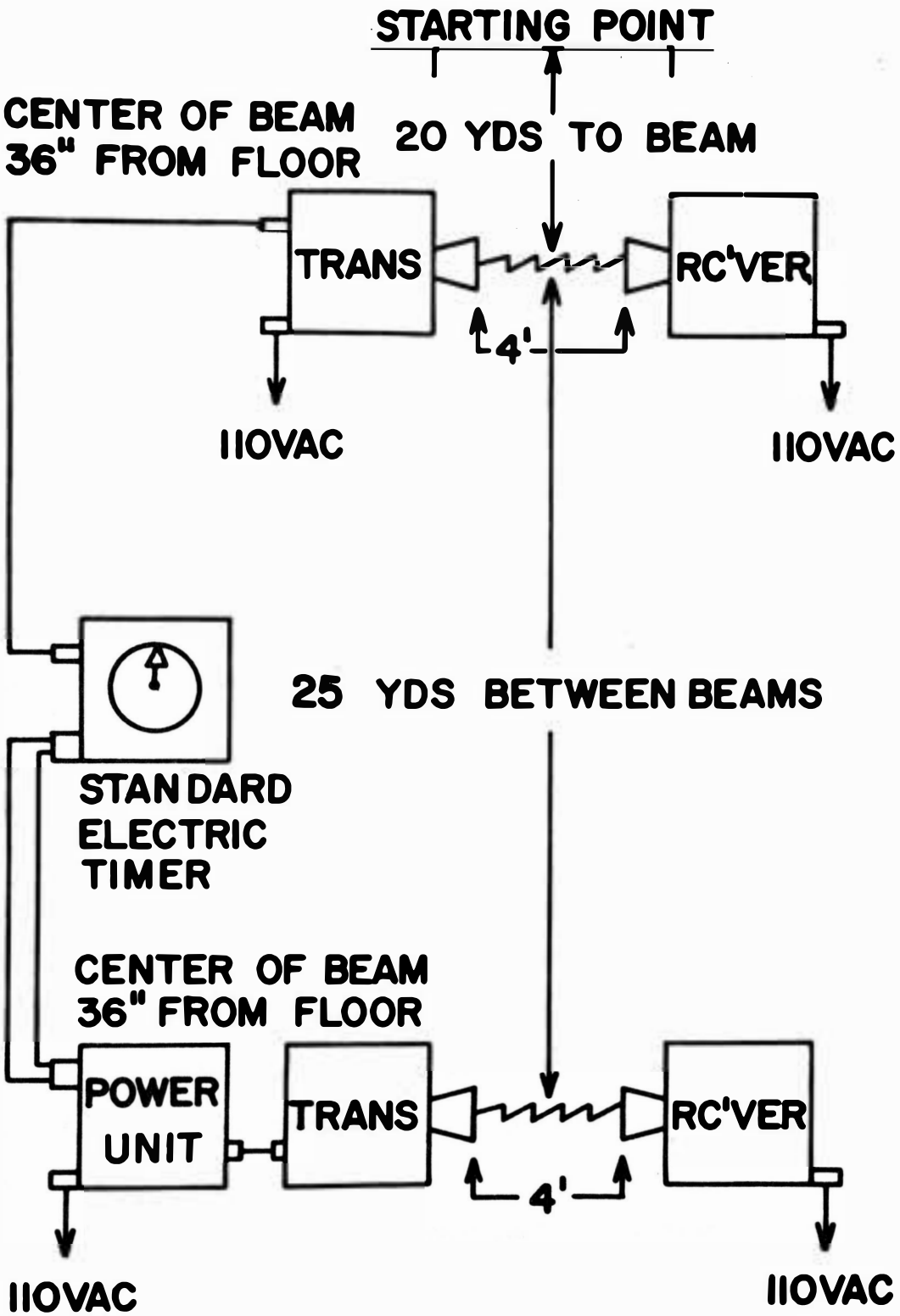

Figure 4. Speed Measuring Apparatus

final post-test. All trials were recorded to the nearest hundredth of a second. The fastest time trial of each subject in the pre-test, initial post-test and the final post-test was the time that was recorded for each test.

The subject was prepared for the free-running speed test by receiving the following instructions from the investigator: "Begin running at maximum speed and do not concentrate on breaking the photo-electric beam, and run the full distance of 45 yards at maximum speed on all trials."

600-Yard Run

The 600-yard run was administered on a 128-yard, banked indoor dirt track. The subjects ran three at a time and were instructed to cover the distance as quickly as possible. The investigator timed the subjects, using two stopwatches, one a split timer, and recorded the time to the nearest one-tenth of a second.

Training Programs

The investigator--through his readings of pertinent literature, through his conversations with other physical educators and coaches, through personal experience in coaching track and field and from claims made by commercial companies--set the following training programs.

The training programs were conducted during 28 training days, from February 7, 1967 to March 17, 1967. The subjects met four or five days a week, depending on the availability of the facilities.

Resistance Running Program

The resistance for this program was offered by a commercial device, the Exer-Genie, and because of the construction of this device, the resistance was found to vary under certain conditions. For this reason the amount of resistance offered by the Exer-Genies used in this investigation was determined by two factors: The number of clicks (14 clicks constituted one complete revolution of the Exer-Genie cylinder) for which the resistance device was set, the fewer number of clicks the smaller the resistance offered; and the time required for the subjects to run the training distance of 39 yards. The training distance of 39 yards was used because of facility limitations.

For each interval bout of resistance running the subjects wore an adjustable canvas belt around the waist. This belt had a metal ring in the back which was the attachment for the rope from the Exer-Genie (Figure 5). A wet towel was provided so that the subjects could clean their gym shoes to increase starting traction.

Before each interval bout of resistance running, the subjects were informed when 15 seconds of the recovery period remained, sufficient time to attach the rope from the Exer-Genie to the metal ring on the back of the canvas belt. With 5 seconds remaining in the recovery period the subjects were given the "Ready" command. At the end of the recovery period the subjects were given the command to "Start." The subjects then ran the 39-yard interval, working against resistance, as quickly as they were capable. The investigator timed each of the running bouts.

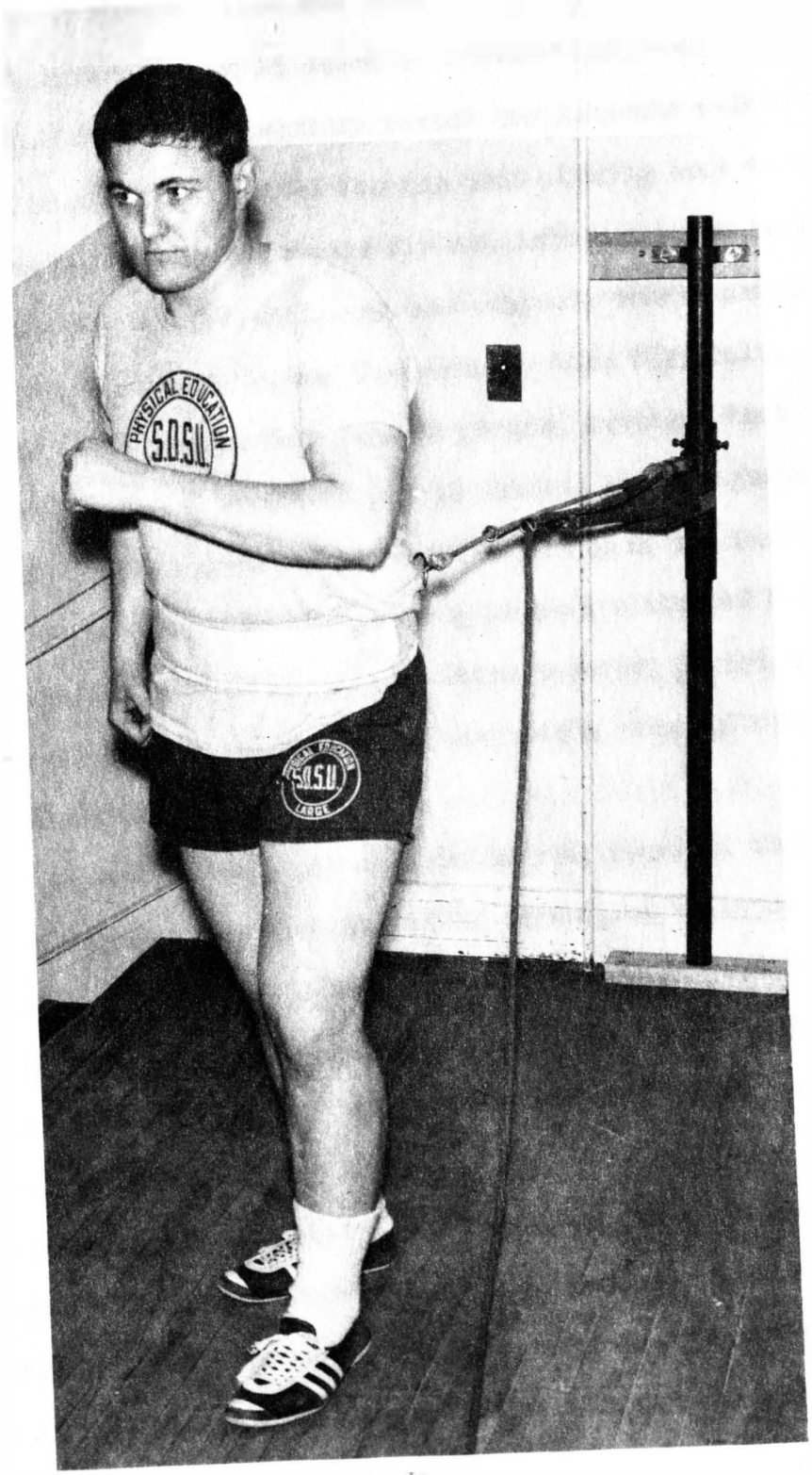

Figure 5. Resistance Running Apparatus

Each recovery period was timed by the investigator, and the subjects were informed when 15 seconds remained before the start of the next bout. During the recovery period the subjects walked back to the starting position and waited for the next running bout to begin.

The 28 training days were divided into six separate levels of either four or six days each. As the subjects progressed through the program the work-load became increasingly more difficult.

The first level, four days in length, required that the subjects work against a resistance of 15 clicks, or an adjustment as the resistance increased due to the heat build-up in the Exer-Genie, and be able to cover one 39-yard running bout in a time of 6.6 to 7.2 seconds. Each subject was given a 3-minute recovery period between each running bout. The subjects completed eight running bouts each day of the first level.

The second level, six days in length, required that the subjects work against a resistance of 15 clicks, or an adjustment as the resistance increased, and be able to cover one 39-yard running bout in a time of 6.6 to 7.2 seconds. The recovery period for the subjects was lowered to 2.5 minutes. The subjects completed eight running bouts each day of the second level.

The third level, four days in length, required that the subjects work against a resistance of 17 clicks, or an adjustment as the resistance increased, and be able to cover one 39-yard running bout in a time of 7.2 to 7.7 seconds. Each subject was given a

3-minute recovery period between each running bout. The subjects completed eight running bouts each day of the third level.

The fourth level, six days in length, required that the subjects work against a resistance of 18 clicks, or an adjustment as the resistance increased, and be able to cover one 39-yard running bout in a time of 7.6 to 8.2 seconds. Each subject was given a 2.5-minute recovery period between each running bout. The subjects completed eight running bouts each day of the fourth level.

The fifth level, four days in length, required that the subjects work against a resistance of 20 clicks, or an adjustment as the resistance increased, and be able to cover one 39-yard running bout in a time of 8.2 to 9.0 seconds. Each subject was given a 3-minute recovery period between each running bout. The subjects completed eight running bouts each day of the fifth level.

The sixth level, four days in length, required that the subjects work against a resistance of 22 clicks, or an adjustment as the resistance increased, and be able to cover one 39-yard running bout in a time of 9.5 to 11.0 seconds. Each subject was given a 2.5-minute recovery period. The subjects completed eight running bouts each day of the sixth level.

Before each day's work the subjects warmed-up by jogging and stretching for 5 minutes. At the end of each day's work the subjects jogged three 39-yard intervals without resistance with a 3-minute walking recovery period following each jogged interval.

Interval Running Program

The interval running program was conducted on a 128-yard, banked indoor dirt track. The track was located in an unheated building and the temperature varied between zero and 40 degrees Fahrenheit during the course of the investigation. The subjects dressed accordingly, wearing either sweat clothes or jeans and a jacket. All subjects wore stocking caps to protect their head and ears and wore rubber-soled gym shoes for ease of running.

Before each interval bout of running the subjects were informed when 15 seconds of the recovery period remained. With 5 seconds remaining in the recovery period, the subjects were given the "Ready" command. At the end of the recovery period the subjects were given the command to "Start." The subjects then ran the 256-yard interval at a predetermined pace. The investigator timed each of the running bouts.

Each recovery period was timed by the investigator and the subjects were informed when 15 seconds remained before the start of the next running bout. During the recovery period the subjects jogged and walked one lap (128 yards) around the track back to the starting position and waited for the next running bout to begin.

The 28 training days were divided into six separate levels of either four or six days each. As the subjects progressed through the program the work load became increasingly more difficult.

The first level, four days in length, required that the subjects run 256 yards (two laps around the track), one running bout,

in 46 seconds or less. Each subject was given a 3-minute recovery period between each running bout. The subjects completed eight running bouts each day of the first level.

The second level, six days in length, was conducted in the same manner as the first level with the exception that the recovery period between each running bout was lowered to 2.5 minutes.

The third level, four days in length, required that the subjects run 256 yards, one running bout, in 44 seconds or less. Each subject was given a 3-minute recovery period between each running bout. The subjects completed eight running bouts each day of the third level.

The fourth level, six days in length, was conducted in the same manner as the third level with the exception that the recovery period between each running bout was lowered to 2.5 minutes.

The fifth level, four days in length, required that the subjects run 256 yards, one running bout, in 42 seconds or less. Each subject was given a 3-minute recovery period between each running bout. The subjects completed eight running bouts each day of the fifth level.

The sixth level, four days in length, required the subjects to run as fast as possible for each 256 yard running bout. Each subject was given a 2.5 minute recovery period between each running bout. The subjects completed eight running bouts each day of the sixth level.

Prior to each work period the subjects jogged two laps (256 yards), completed stretching exercises on his own and then jogged a fast lap (128 yards) as a warm-up before starting the required work.

At the completion of each day's work the subjects walked a lap, jogged a lap and walked a lap as a warm-down.

Chapter IV

ANALYSIS OF DATA

Introduction

The statistical analysis of the data collected is presented in this chapter. Data were collected at pre-test, initial post-test, and final post-test intervals on oxygen debt repaid during recovery from a standard treadmill run, power developed by the legs, free running speed over a distance of 25 yards, and the elapsed time for the 600-yard run. (The raw data appear in the Appendixes A - D.) The pre-test was administered on January 23 and 24, 1967 and the initial post-test on March 19 and 20, 1967. The final post-test was administered on March 30 and 31, 1967.

Scoring of Data

The raw scores obtained from the free running speed and the 600-yard run required no conversion in this investigation. The raw scores obtained for the amount of oxygen consumed during rest and in recovery from a standardized treadmill run were doubled because of the use of a 13.5-liter respirometer. Also, a correction factor, determined from oxygen temperature and barometric pressure, was employed to compute the corrected amount of oxygen consumed at rest and during recovery. The raw scores obtained from the modification of the vertical power jump test were recorded in inches and converted to feet by dividing each score by twelve. The resulting quotient was then

multiplied by the subject's weight, taken to the nearest one-half pound, to give the foot-pounds of power developed by each subject. (The raw data appear in Appendixes E and F.)

Reliability of Data

Oxygen Debt Repaid

Reliability coefficients were not computed for the amount of oxygen consumed during the five-minute rest nor for the oxygen debt repaid during the recovery from exercise. After each subject used the equipment, the investigator employed a standard procedure of checking the soda-lime crystals, the hoses and valves, and the respirometer.

Power

The test used to measure power was a modification of a leg power test devised by Gray et al.[23] These investigators determined leg

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[23] R. K. Gray, K. B. Start and D. J. Glencross, "A Test of Leg Power," Research Quarterly, March, 1962, p. 44.

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power in terms of the physical principle, power equals work over time. This leg power test had a test-retest correlation coefficient of .985 and a coefficient of objectivity of .981. The authors concluded that the test was valid for measuring the power of the legs developed in a vertical jump. The modified leg power test was used in the present study because of the ease of administration and difficulty in employing the leg power test as originally developed by Gray and his associates. The modified leg power test converted inches jumped to foot-pounds of

work performed and was found by Gray et al.[24] in a later study to

[24] R. K. Gray, K. B. Start and D. J. Glencross, "A Useful Modification of the Vertical Power Jump," Research Quarterly, May, 1962, p. 230.

correlate .989 with the original criterion measure of power.

Free Running Speed

The reliability of the free running speed test was determined by the test-retest method, as employed by Fritz.[25] A rank order

[25] William E. Fritz, "Effect of a Trampoline Training Program on Selected Items of Motor Fitness," M. S. Thesis, South Dakota State University, 1965, p. 23.

correlation of +.90 was established.

600-Yard Run

The 600-yard run had a reliability of +.80 for cardiovascular endurance as established by Fleishman[26] in a study involving 20,000

[26] Edwin A. Fleishman, Examiner's Manual for the Basic Fitness Tests, p. 24.

subjects.

Analysis of Data

The analysis of data for this investigation dealt statistically with the mean gain or loss difference between the two experimental and the control groups. Statistical procedures were also applied to the mean gain or loss difference between the pre-test,

initial post-test, and final post-test within the two experimental groups and the control group. The investigator employed the statistical procedures as suggested by Steel and Torrie[27] to determine

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[27] Robert G. D. Steel and James H. Torrie, Principles and Procedures of Statistics, p. 107.

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the analysis of variance and Duncan's New Multiple-Range Test. The Duncan New Multiple-Range Test was applied when the F-ratio indicated or approached statistical significance. The .05 level of significance and the .01 level of significance were chosen to denote statistically significant differences for the analysis of variance. A statistical coefficient at or beyond the .01 level or the .05 level necessitated a rejection of the null hypotheses. Fourteen degrees of freedom were used in this investigation. When Duncan's New Multiple-Range Test was employed, a protection level of .98 was used for the .01 level and .90 for the .05 level.

Findings

Analysis of Variance (Between Groups)

Analysis of variance was applied between the two experimental groups and the control group to determine significance of difference for oxygen debt repaid, power, free running speed, and the 600-yard run. The following table (Table I) presents the statistical data concerning the difference of means on the pre-test, initial post-test, and the final post-test for all of the test items.

Table I

Summary of Analysis of Variance of Difference between Group Means

of Pre-test, Initial Post-test, and Final Post-test

Measurement	df	Variance among Means	Variance within Groups	F-ratio	Level of Significance
Oxygen Debt Repaid (CC)					
Pre-test	2/42	59,652	364,758	0.16	NS
Initial Post-test	2/42	1,101,722	288,384	3.86	.05
Final Post-test	2/42	753,580	554,313	1.36	NS
Power (Ft. Lbs.)					
Pre-test	2/42	2.2	657.4	0.00	NS
Initial Post-test	2/42	202.1	667.0	0.30	NS
Final Post-test	2/42	235.3	627.7	0.38	NS
Free Running Speed (Sec.)					
Pre-test	2/42	0.016	0.016	0.94	NS
Initial Post-test	2/42	0.015	0.027	0.56	NS
Final Post-test	2/42	0.005	0.020	0.25	NS
600 Yard Run (Sec.)					
Pre-test	2/42	61.4	76.7	0.80	NS
Initial Post-test	2/42	218.0	39.8	5.58	.01
Final Post-test	2/42	106.9	41.8	2.56	NS

Oxygen Debt Repaid

The F-ratio was computed for the initial post-test and found to be 3.86 (Table I). This was statistically significant at the .05 level of significance.

The F-ratio was computed for the final post-test and found to be 1.36 (Table I). This was not statistically significant for this study.

Power

The F-ratio was computed for the initial post-test and found to be 0.30 (Table I). This was not statistically significant for this study.

The F-ratio was computed for the final post-test and found to be 0.38 (Table I). This was not statistically significant for this study.

Free Running Speed

The F-ratio was computed for the initial post-test and found to be 0.56 (Table I). This was not statistically significant for this study.

The F-ratio was computed for the final post-test and found to be 0.25 (Table I). This was not statistically significant for this study.

600-Yard Run

The F-ratio was computed for the initial post-test and found to be 5.48 (Table I). This was statistically significant beyond the .01 level of significance.

The F-ratio was computed for the final post-test and found to be 2.56 (Table I). This was not statistically significant for this study.

Analysis of Variance (Within Groups)

Analysis of variance was applied within the two experimental groups and the control group to determine significance of difference for oxygen debt repaid, power, free running speed, and the 600-yard run. The following table (Table II) presents the statistical data concerning the difference of means on the pre-test, initial post-test, and the final post-test on all of the test items.

The F-ratio was computed for the oxygen debt repaid, power, free running speed, and the 600-yard run within the control group; and no significance was found for this study.

Oxygen Debt Repaid

The F-ratio was computed for the resistance running group and found to be 0.00 (Table II). This was not statistically significant for this study.

The F-ratio was computed for the interval running group and found to be 0.20 (Table II). This was not statistically significant for this study.

Table II

Summary of Analysis of Variance of Difference within Groups Means of Pre-test, Initial Post-test, and Final Post-test

Measurement	df	Variance among Means	Variance within Groups	F-ratio	Level of Significance
Oxygen Debt Repaid (CC)					
Resistance Group	2/42	1,288	335,045	0.00	NS
Interval Group	2/42	49,654	249,809	0.20	NS
Power (Ft. Lbs.)					
Resistance Group	2/42	639.5	592.6	1.08	NS
Interval Group	2/42	533.0	707.3	.76	NS
Free Running Speed (Sec.)					
Resistance Group	2/42	0.000	0.022	0.00	NS
Interval Group	2/42	0.005	0.015	0.33	NS
600 Yard Run (Sec.)					
Resistance Group	2/42	87.7	59.9	1.46	NS
Interval Group	2/42	166.3	61.5	2.70	NS

Power

The F-ratio was computed for the resistance running group and found to be 1.03 (Table II). This was not statistically significant for this study.

The F-ratio was computed for the interval running group and found to be 1.67 (Table II). This was not statistically significant for this study.

Free Running Speed

The F-ratio was computed for the resistance running group and found to be 0.00 (Table II). This was not statistically significant for this study.

The F-ratio was computed for the interval running group and found to be 0.33 (Table II). This was not statistically significant for this study.

600-Yard Run

The F-ratio was computed for the resistance running group and found to be 1.46 (Table II). This was not statistically significant for this study.

The F-ratio was computed for the interval running group and found to be 2.70 (Table II). This was not statistically significant for this study.

Duncan's New Multiple-Range Test (Between Groups)

Duncan's New Multiple-Range Test was applied to the data concerning oxygen debt repaid and the 600-yard run. Because of the results of the application of the F-ratio and no indication of approaching significant difference, data on power and free running speed were not treated statistically by the use of Duncan's New Multiple-Range Test.

Oxygen Debt Repaid

The Duncan's New Multiple-Range Test was employed to compare the following pairs of means: the control group to the interval group, control group to the resistance group, and interval group to the resistance group on the pre-test, initial post-test, and the final post-test. A score of 539.3 (Table III) was found between the control group and the interval group on the initial post-test; and this was significant beyond the .05 protection level.

600-Yard Run

The Duncan's New Multiple-Range Test was employed to compare the following pairs of means: the control group to the interval group, control group to the resistance group, and the interval group to the resistance group on the pre-test, initial post-test, and the final post-test. A score of 6.80 (Table III) was found between the control group and the interval group on the initial post-test. This was significant beyond the .01 protection level. A score of 5.30

Table III

Summary of Duncan's New Multiple Range Test for Oxygen Debt Repaid and 600-Yard Run, between Groups

Oxygen Debt Repaid
Initial Post-test

Rank	1	2	3
Mean	2771.8	3030.1	3311.2
Group	Interval	Resistance	Control

600-Yard Run
Initial Post-test

Rank	1	2	3
Mean	95.6	99.4	102.4
Group	Interval	Resistance	Control

600-Yard Run
Final Post-test

Rank	1	2	3
Mean	97.9	101.2	103.2
Group	Interval	Resistance	Control

Any two means not underscored by the same line are significantly different.
Any two means underscored by the same line are not significantly different.
Protection level is .98 at .01 level and .90 at .05 level (Alpha error .05 when 3 groups compared)

(Table III) was found between the control group and the interval group on the final post-test. This was significant beyond the .05 protection level.

Duncan's New Multiple-Range Test (Within Groups)

Duncan's New Multiple-Range Test was applied to the data concerning oxygen debt repaid and the 600-yard run. Because of the results of the application of the F-ratio and no indication of approaching significant difference, data on power and free running speed were not treated statistically by the use of Duncan's New Multiple-Range Test.

Oxygen Debt Repaid

The Duncan New Multiple-Range Test was employed to compare the following pairs of means: the pre-test to the initial post-test, pre-test to the final post-test, and the initial post-test to the final post-test in the control group, resistance group, and the interval group. For this investigation no significance was found (Table IV).

600-Yard Run

The Duncan New Multiple-Range Test was employed to compare the pre-test to the initial post-test, pre-test to the final post-test, and the initial post-test to the final post-test in the control group, resistance group, and the interval group. A score of 6.7 (Table IV) was found between the pre-test and the initial post-test for the

Table IV

Summary of Duncan's New Multiple-Range Test for Oxygen Debt Repaid and 600-Yard Run, within Groups

	Oxygen Debt Repaid Control Group		
Rank	1	2	3
Mean	2954.0	3264.8	3311.2
Group	Pre-test	Final Post-test	Initial Post-test
	600-Yard Run Interval Group		
Rank	1	2	3
Mean	95.6	97.9	102.3
Group	Initial Post-test	Final Post-test	Pre-test

Any two means not underscored by the same line are significantly different.
Any two means underscored by the same line are not significantly different.
Protection level is .98 at .01 level and .90 at .05 level. (Alpha error .05 when 3 groups compared)

interval group. This was significant beyond the .05 protection level. For this investigation no other significance was found for the 600-yard run within the groups (Table IV).

Summary of Findings

Statistically significant improvement was noted for the interval group in oxygen debt repaid on the initial post-test and for the 600-yard run on the initial post-test and the final post-test, by use of the analysis of variance and Duncan's New Multiple-Range Test.

Statistically significant improvement was noted within the interval group between the pre-test and the initial post-test for the 600-yard run as determined by the use of the analysis of variance and Duncan's New Multiple-Range Test.

Discussion of Findings

The statistically significant improvement, as noted within the interval group and also when the interval group was compared to the resistance and control groups for oxygen debt repaid and the 600-yard run, was the result that would be expected. Similar results have been reported in the literature for this type of training program. Interval training has been accepted as a method of training for improving circulorespiratory efficiency.

The writer felt that the resistance group did not show significant improvement for the 600-yard run and the free running speed test because of the difficulty they experienced, during the two

post-test, in running without resistance. The resistance running group developed a running form that appeared to hamper free running when attempting to run without resistance.

The temperature difference, 40 degrees Fahrenheit, between the pre-test and the two post-tests for the 600-yard run may have affected the resulting statistical analysis.

The writer cannot explain why the resistance running group did not make significant gains in oxygen debt repaid and power.

Chapter V

SUMMARY

Problem

The purpose of this investigation was to determine the effects of a selected resistance running program on circulorespiratory efficiency, power, and free running speed.

A selected interval training program was employed in order to compare the progressive resistance training program to an accepted method of training.

Data

Subjects who participated in this investigation were freshman male students in the physical education basic instruction program at South Dakota State University during the spring semester 1967. The subjects were selected randomly from 151 volunteers. A six-week training program, 28 sessions in length, was administered to the two experimental groups, each composed of 15 subjects. An additional 15 subjects acted as a control group. The resistance running experimental group worked against a predetermined amount of resistance, offered by a commercial device, the Exer-Genie. The interval running experimental group employed a selected interval training program. The work load for both groups was gradually increased throughout the program.

Tests were administered at the beginning of the investigation, and immediately following the training program the initial

post-test was administered. Ten days after the completion of the initial post-test the final post-test was administered. The tests employed were oxygen debt repaid to determine circulorespiratory efficiency, power developed by the legs, free running speed, and the time of the 600-yard run.

Data obtained during testing were recorded and analyzed by employing analysis of variance (F-ratio) and Duncan's New Multiple-Range Test.

Findings

1. No statistically significant difference was found within the resistance running group or between the resistance running group and either the control or the interval running group for oxygen debt repaid, power, free running speed, and the elapsed time for the 600-yard run.

2. The interval running group made statistically significant improvements when compared to the control group, from pre-test to initial post-test, for oxygen debt repaid, which indicated improvement in circulorespiratory efficiency.

3. The interval running group made statistically significant improvement when compared to the control group, from pre-test to initial post-test and from pre-test to final post-test, for the 600-yard run.

4. The interval running group made statistically significant improvement from pre-test to initial post-test on the 600-yard run.

Conclusions

From the findings of this investigation the following conclusions were drawn: That an interval training program is a more effective method of increasing circulorespiratory efficiency and decreasing running time for 600 yards than the resistance running program; that a program of resistance running or interval training does not appear to affect significantly speed and power.

Recommendations for Further Study

Based on the information obtained in this investigation, the investigator would make the following recommendations for further study:

1. That a similar study be conducted where the experimental group alternates resistance running with a standard interval training program.

2. That a similar study be conducted to investigate the results of a resistance running program using light resistance and an increased running distance.

3. That a similar study be conducted to investigate the results of an overload resistance running program (heavy resistance and few repetitions).

4. That a similar study be conducted to investigate the results of a resistance running program on heart rate, selected body girth measurements, and adipose tissue.

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APPENDIXES

Appendix A

RAW DATA: OXYGEN DEBT (CC. OXYGEN)

	Pre-Test	Initial Post Test	Final Post Test
Resistance Running Group			
Subject Number			
1	2129.4	1424.6	2725.8
2	3594.8	3543.2	3564.0
3	3019.2	2037.6	2268.0
4	2898.0	3048.8	3264.0
5	2501.7	3226.2	3041.4
6	2619.5	3042.0	2366.4
7	3248.0	2307.4	1962.5
8	2514.0	2940.0	2656.0
9	3685.5	3427.2	3710.8
10	3366.1	3859.2	2948.9
11	3825.8	3633.5	4060.0
12	3894.4	2748.9	3470.1
13	2116.4	3469.2	3009.3
14	3203.2	3056.2	3267.7
15	3564.0	3687.2	3053.7
Interval Running Group			
Subject Number			
1	1786.4	2410.8	2273.6
2	3778.8	3016.8	2894.4
3	2582.3	1797.6	2630.1
4	2604.0	2750.5	2415.7
5	3166.8	2818.2	2663.1
6	2704.0	2456.3	3208.0
7	3135.6	3464.5	3019.2
8	3386.6	3024.0	3418.5
9	2758.8	2249.1	2517.2
10	3004.4	2795.1	3345.6
11	3778.8	3248.7	3469.2
12	2937.6	3108.0	2791.4
13	2293.2	2243.7	2545.1
14	2424.4	3201.9	1673.7
15	2948.4	2991.6	3388.4

Appendix A (continued)

RAW DATA: OXYGEN DEBT (CC. OXYGEN)

Control Group Subject Number	Pre-Test	Initial Post Test	Final Post Test
1	2988.0	3159.8	3216.0
2	2189.2	3226.2	3407.1
3	2434.4	2202.2	2973.6
4	2604.8	3295.5	3251.3
5	3166.8	2957.5	2400.0
6	3108.0	2849.2	2332.4
7	2853.0	3594.8	3530.3
8	3045.1	3034.8	4512.4
9	2926.0	3793.5	3147.8
10	4698.0	3324.0	3656.4
11	3816.0	4609.0	4064.7
12	2523.0	3624.9	2480.0
13	2692.8	4096.4	2789.5
14	2016.4	3212.0	3600.0
15	3248.0	2688.0	3600.0

Appendix B

RAW DATA: POWER (FOOT POUNDS)

	Pre-Test	Initial Post Test	Final Post Test
Resistance Running Group			
Subject Number			
1	150.17	180.47	204.17
2	203.06	208.41	213.75
3	170.37	160.42	187.69
4	150.00	140.62	156.29
5	150.50	146.39	173.82
6	161.10	142.44	150.33
7	174.78	180.53	173.38
8	149.79	130.00	179.90
9	127.19	141.97	129.38
10	170.04	151.50	153.75
11	201.67	165.47	157.50
12	126.63	142.19	162.25
13	180.00	159.60	186.75
14	135.56	126.31	141.00
15	208.44	200.58	203.00
Interval Running Group			
Subject Number			
1	167.44	136.88	167.86
2	190.50	194.82	175.50
3	135.00	135.00	152.08
4	186.60	160.31	185.25
5	129.53	137.38	139.13
6	231.28	185.19	207.81
7	200.58	186.20	192.50
8	158.14	163.94	171.50
9	130.82	147.00	150.57
10	147.00	158.13	156.10
11	148.83	159.58	173.34
12	139.69	152.10	159.38
13	149.04	145.17	161.00
14	169.00	213.75	208.96
15	183.00	192.83	221.73

Appendix B (continued)

RAW DATA: POWER (FOOT POUNDS)

Control Group Subject Number	Pre-Test	Initial Post Test	Final Post Test
1	216.13	212.55	218.85
2	171.50	163.39	136.56
3	145.00	154.88	158.67
4	134.15	128.33	127.56
5	157.00	162.09	154.03
6	165.21	124.69	150.47
7	177.11	144.11	166.27
8	181.42	195.15	190.00
9	188.12	200.63	204.60
10	141.31	157.03	152.63
11	164.16	164.69	153.24
12	131.63	174.41	147.88
13	138.88	142.97	161.46
14	180.64	183.04	179.06
15	162.87	167.85	203.12

Appendix C

RAW DATA: FREE RUNNING SPEED (SECONDS)

	Pre-Test	Initial Post Test	Final Post Test
Resistance Running Group			
Subject Number			
1	2.77	2.64	2.69
2	2.67	2.68	2.84
3	2.74	2.77	2.83
4	2.95	2.92	2.92
5	2.80	2.72	2.71
6	2.85	2.94	3.08
7	2.89	2.69	2.74
8	2.77	2.76	2.78
9	3.22	3.22	3.15
10	3.04	3.04	3.08
11	2.85	2.92	2.92
12	2.79	2.85	2.71
13	2.84	2.81	2.82
14	3.03	3.00	2.87
15	2.77	2.85	2.88
Interval Running Group			
Subject Number			
1	2.83	2.86	2.77
2	2.92	2.63	2.76
3	2.85	2.87	2.88
4	2.73	2.75	2.76
5	2.88	2.70	2.88
6	2.75	2.70	2.65
7	2.89	3.00	2.81
8	2.94	2.82	2.94
9	2.81	2.96	2.92
10	2.95	2.84	2.96
11	3.02	3.06	3.02
12	3.00	3.11	2.94
13	2.97	2.96	2.91
14	2.83	2.73	2.79
15	2.99	3.07	3.08

Appendix C (continued)

RAW DATA: FREE RUNNING SPEED (SECONDS)

Control Group Subject Number	Pre-Test	Initial Post Test	Final Post Test
1	2.83	2.79	2.81
2	2.89	2.84	2.79
3	2.87	2.83	2.83
4	2.93	2.99	2.97
5	3.00	3.04	2.97
6	2.68	2.58	2.59
7	2.92	3.35	3.20
8	2.85	2.85	2.83
9	3.12	3.04	3.04
10	3.15	3.09	3.08
11	2.95	2.82	2.95
12	3.17	3.00	3.02
13	2.91	3.87	2.82
14	2.90	2.91	2.82
15	2.75	2.68	2.71

Appendix D

RAW DATA: 600 YARD RUN (SECONDS)

	Pre-Test	Initial Post Test	Final Post Test
Resistance Running Group			
Subject Number			
1	94.2	90.4	89.8
2	103.2	95.7	96.8
3	97.4	92.2	97.8
4	102.0	97.4	99.4
5	98.5	94.1	93.3
6	102.6	97.8	109.2
7	96.0	95.3	96.1
8	102.4	106.3	107.7
9	111.3	110.6	106.9
10	116.0	112.4	108.4
11	101.8	102.4	102.4
12	106.9	97.9	96.8
13	97.7	97.3	102.9
14	130.4	109.4	113.0
15	102.7	92.1	97.8
Interval Running Group			
Subject Number			
1	97.1	95.2	98.1
2	95.7	85.8	92.1
3	98.9	87.1	90.4
4	90.9	90.2	91.9
5	98.8	93.5	96.0
6	96.3	88.5	92.7
7	106.7	100.3	100.9
8	107.8	95.4	94.6
9	96.0	95.2	93.7
10	110.7	99.6	101.8
11	111.2	105.3	109.6
12	109.4	100.3	100.2
13	102.2	94.0	94.4
14	104.4	101.1	104.9
15	107.8	102.7	107.2

Appendix D (continued)

RAW DATA: 600 YARD RUN (SECONDS)

Control Group Subject Number	Pre-Test	Initial Post Test	Final Post Test
1	102.5	98.0	97.6
2	103.4	98.4	101.4
3	109.6	102.0	102.8
4	101.2	103.0	96.6
5	113.8	116.0	114.1
6	94.9	94.4	92.1
7	104.6	105.0	106.2
8	107.8	100.2	96.8
9	114.0	104.9	116.9
10	109.4	102.5	104.1
11	105.1	102.5	102.6
12	114.7	111.9	111.0
13	110.0	103.8	104.1
14	101.1	98.2	102.3
15	102.5	95.2	99.1

Appendix E

RAW DATA: WEIGHT (POUNDS)

	Pre-Test	Initial Post Test	Final Post Test
Resistance Running Group			
Subject Number			
1	136.0	137.5	140.0
2	171.0	175.5	180.0
3	141.0	140.0	143.0
4	150.0	150.0	150.0
5	150.5	149.5	149.0
6	164.5	159.0	164.0
7	144.5	163.5	165.5
8	153.0	156.0	157.0
9	203.5	206.5	207.0
10	199.0	202.0	205.0
11	176.0	176.5	180.0
12	167.5	175.0	177.0
13	160.0	163.0	166.0
14	141.5	141.0	141.0
15	164.0	166.0	168.0
Interval Running Group			
Subject Number			
1	141.0	146.0	146.5
2	155.0	158.5	162.0
3	144.5	144.0	146.0
4	169.0	171.0	171.0
5	155.0	157.0	159.0
6	173.5	171.0	175.0
7	165.5	162.5	165.0
8	176.5	183.0	179.0
9	146.0	144.0	147.5
10	126.0	126.5	127.0
11	188.0	191.5	193.5
12	149.5	149.0	150.0
13	134.0	134.0	138.0
14	169.0	171.0	170.0
15	183.0	178.0	183.5

Appendix E (continued)

RAW DATA: WEIGHT (POUNDS)

Control Group Subject Number	Pre-Test	Initial Post Test	Final Post Test
1	182.0	185.5	191.0
2	168.0	170.5	172.5
3	116.0	118.0	119.0
4	157.0	154.0	157.0
5	137.0	136.5	139.5
6	152.5	157.5	160.5
7	173.5	173.0	173.5
8	155.5	161.5	160.0
9	210.0	214.0	213.5
10	161.5	167.5	166.5
11	154.5	155.0	156.5
12	175.5	182.0	182.0
13	151.5	152.5	155.0
14	188.5	191.0	191.0
15	147.5	146.5	150.0

Appendix F

RAW DATA: POWER JUMP (INCHES)

	Pre-Test	Initial Post Test	Final Post Test
Resistance Running Group			
Subject Number			
1	13.25	15.75	17.50
2	14.25	14.25	14.25
3	14.50	13.75	15.75
4	12.00	11.25	12.50
5	12.00	11.75	14.00
6	11.75	10.75	11.00
7	12.75	13.25	12.50
8	11.75	10.00	13.75
9	7.50	8.25	7.50
10	10.25	9.00	9.00
11	13.75	11.25	10.50
12	9.00	9.75	11.00
13	13.50	11.75	13.50
14	11.50	10.75	12.00
15	15.25	14.50	14.50
Interval Running Group			
Subject Number			
1	14.25	11.25	13.75
2	14.75	14.75	13.00
3	11.25	11.25	12.50
4	13.25	11.25	13.00
5	10.00	10.50	10.50
6	16.00	13.00	14.25
7	14.50	13.75	14.00
8	10.75	10.75	11.50
9	10.75	12.25	12.25
10	14.00	15.00	14.75
11	9.50	10.00	10.75
12	11.25	12.25	12.75
13	13.25	13.00	14.00
14	12.00	15.00	14.75
15	12.00	13.00	14.50

Appendix F (continued)

RAW DATA: POWER JUMP (INCHES)

Control Group Subject Number	Pre-Test	Initial Post Test	Final Post Test
1	14.25	13.75	13.75
2	12.25	11.50	9.50
3	15.00	15.75	16.00
4	10.25	10.00	9.75
5	13.75	14.25	13.25
6	13.00	9.50	11.25
7	12.25	10.00	11.50
8	14.00	14.50	14.25
9	10.75	11.25	11.50
10	10.50	11.25	11.00
11	12.75	12.75	11.75
12	9.00	11.50	9.75
13	11.00	11.25	12.50
14	11.50	11.50	11.25
15	13.25	13.75	16.25

Appendix G

MEANS OF RAW DATA

	Pre-Test	Initial Post Test	Final Post Test
Control Group			
Oxygen Debt Repaid (cc)	2954.0	3311.2	3264.8
Power (Ft. Lbs.)	163.68	165.05	166.96
Free Running Speed (Sec.)	2.928	2.912	2.890
600-Yard Run (Sec.)	106.3	102.4	103.2
Power Jump (Inches)	12.2	12.2	12.2
Weight (Lbs.)	160.0	164.3	165.8
Resistance Group			
Oxygen Debt Repaid (cc)	3012.0	3030.1	3024.6
Power (Ft. Lbs.)	163.95	158.46	171.53
Free Running Speed (Sec.)	2.865	2.854	2.868
600-Yard Run (Sec.)	104.2	99.4	101.2
Power Jump (Inches)	12.2	11.7	12.6
Weight (Lbs.)	161.5	164.1	166.2
Interval Group			
Oxygen Debt Repaid (cc)	2886.0	2771.8	2816.9
Power (Ft. Lbs.)	164.43	164.57	174.85
Free Running Speed (Sec.)	2.891	2.871	2.871
600-Yard Run (Sec.)	102.3	95.6	97.9
Power Jump (Inches)	12.5	12.8	13.1
Weight (Lbs.)	158.4	159.0	160.9